

NUCLEAR AIR CLEANING HANDBOOK

TABLE OF CONTENTS

| | | |
|-----------|--|------------|
| 1. | History of the Development of Air Cleaning Technology in the Nuclear Industry | 1 |
| 1.1 | Brief History of Nuclear Aerosol Filtration | 1 |
| 1.2 | Deep-Bed Sand and Glass Fiber Filters..... | 8 |
| 1.3 | Brief History of Gas Adsorption | 9 |
| 1.4 | Adsorbent Bed Sizing for Noble Gas Delay | 13 |
| 1.5 | References | 14 |
| 2. | System Considerations | 19 |
| 2.1 | Introduction | 19 |
| 2.2 | Environmental Considerations | 19 |
| 2.3 | General System Considerations | 31 |
| 2.4 | Air Cleaning System Design Considerations for Commercial Nuclear Power Plant Systems | 33 |
| 2.5 | Air Cleaning Systems for Fuel Processing and Reprocessing Plants..... | 56 |
| 2.6 | Operational Considerations..... | 58 |
| 2.7 | Special Considerations..... | 67 |
| 2.8 | Emergency Considerations | 69 |
| 2.9 | Air Sampling..... | 72 |
| 2.10 | References for Chapter 2 | 73 |
| 3. | Filters for the Nuclear Industry..... | 77 |
| 3.1 | Introduction | 77 |
| 3.2 | Filtration | 78 |
| 3.3 | HEPA Filters | 80 |
| 3.4 | Prefilters for HEPA Filters..... | 100 |
| 3.5 | Deep-Bed Filters | 103 |
| 3.6 | Demisters..... | 106 |
| 3.7 | Filter Selection | 107 |
| 3.8 | References | 108 |
| 4. | House Design and Layout..... | 111 |
| 4.1 | Introduction | 111 |
| 4.2 | Housing System Design | 111 |
| 4.3 | Component Installation..... | 115 |
| 4.4 | Man Entry Housing | 118 |

| | | |
|-----------|--|------------|
| 4.5 | Side-Access Housings..... | 150 |
| 4.6 | References | 163 |
| 5. | External Components..... | 165 |
| 5.1 | Introduction..... | 165 |
| 5.2 | Ductwork..... | 165 |
| 5.3 | Dampers and Louvers | 174 |
| 5.4 | Fans and Motors..... | 181 |
| 5.5 | Air Intakes and Stacks | 192 |
| 5.6 | Instrumentation and Control..... | 196 |
| 5.7 | Other Considerations | 198 |
| 5.8 | References | 198 |
| 6. | Small Air Cleaning Units | 203 |
| 6.1 | Introduction | 203 |
| 6.2 | Housing..... | 205 |
| 6.3 | Enclosed Filter Installation..... | 212 |
| 6.4 | Cylindrical Filter | 213 |
| 6.5 | Installation..... | 215 |
| 6.6 | References | 224 |
| 7. | Glovebox Filtration..... | 227 |
| 7.1 | Introduction | 227 |
| 7.2 | Design of Glovebox Ventilation System | 230 |
| 7.3 | Glovebox Filter Installation..... | 238 |
| 7.4 | Filter Replacement | 245 |
| 7.5 | Glovebox Safety | 247 |
| 7.6 | References | 256 |
| 8. | Testing..... | 257 |
| 8.1 | Introduction | 257 |
| 8.2 | Proof of Design – HEPA Filter Qualification for Nuclear Service..... | 258 |
| 8.3 | Quality Assurance Inspection and Testing of HEPA Filters..... | 262 |
| 8.4 | Visual Inspection..... | 263 |
| 8.5 | In-Place Component Tests and Criteria | 263 |
| 8.6 | Surveillance Testing | 270 |
| 8.7 | In-Place Testing for Multistage Systems..... | 280 |
| 8.8 | Needed Improvements..... | 288 |
| 8.9 | Review of In-Place Filter Testing at Selected DOE Sites | 290 |
| 8.10 | HEPA Filter Vacuum Cleaners and Portable HEPA Filtration Systems | 291 |
| 8.11 | References | 294 |

| | | |
|------------|---|------------|
| 9. | Special Application Requirements | 297 |
| 9.1 | Introduction | 297 |
| 9.2 | Remote Maintenance of Hot Cells | 297 |
| 9.3 | Shielding..... | 307 |
| 9.4 | Natural Phenomena | 308 |
| 9.5 | Deep-Bed Sand Filters..... | 322 |
| 9.6 | Reactor Engineered Safety Feature Air Cleaning System..... | 330 |
| 9.7 | Fuel Reprocessing Plant Air Cleaning..... | 334 |
| 9.8 | References | 337 |
| 10. | Fire Protection | 341 |
| 10.1 | Introduction | 341 |
| 10.2 | Fire History | 342 |
| 10.3 | Codes and Standards..... | 343 |
| 10.4 | Enclosure Fire Modeling in Fire Hazards Analysis | 345 |
| 10.5 | Fire Phenomena | 346 |
| 10.6 | Fire Hazard Controls and Design Features..... | 356 |
| 10.7 | Operations and Maintenance Practices for Fire Protection of Confinement Ventilation Systems..... | 369 |
| 10.8 | Generic Firefighting Procedures..... | 370 |
| 10.9 | References | 373 |
| 11. | Industrial Hygiene, Health Physics, and Occupational Safety | 375 |
| 11.1 | Industrial Hygiene..... | 375 |
| 11.2 | Health Physics..... | 380 |
| 11.3 | Occupational Safety | 386 |
| 11.4 | References | 388 |